Holden Municipal Light Department

Stray Voltage Investigation
September 4, 2014

- Over the past several weeks, the Light Department has been investigating reports of low levels of stray voltage in a localized area of town.

- As part of our investigation, we have taken the following steps to locate the cause and correct it:

    - Tested all the circuits in the area, isolating and testing each transformer;
    - Reconfigured the system and changed the circuit that feeds the area;
    - Completely denergized and isolated the area, only to find that the low levels of stray voltage were still present; and
    - Installed a device in the area designed to eliminate the stray voltage.

- Each of these actions has resulted in power outages to portions of or the entire area involved. This has been disruptive to customers, especially when coupled with recent storms and a motor vehicle accident in the area that have caused separate outages.

- Thus far, our efforts have only been partially successful and have reduced the low level of stray voltage by a small amount.

- The low levels of stray voltage being detected are in the 1-3 volt range. One location was measured at 5 volts, but that has been reduced to below 3 volts. (Normal house current is in the 120-240 volt range, with most appliances using 120 volts.)

- Stray voltage is most often the result of the configuration of the local electric distribution system, such as the Light Department. However, it is not the potential sole source and can be from other sources such as the customer's own wiring system, a neighbor's wiring system, another utility such as the phone, cable, pipe line or any combination of the above.

- Seeing how our actions are not fully addressing the matter, we have contacted Charter Cable and Verizon and asked them to perform their own investigations.

- We continue our investigation and have sought the assistance of electrical experts and an electrical engineering firm.

- For more information on stray voltage, please refer to attached the Power Quality Bulletin issued by a large electric utility.

- Since the cause can be from a variety of sources, the process of locating it may take time. There may be more than one source.

- We will provide additional information as it becomes available.

Stray Voltage

Have you ever been shocked near a swimming pool when you touched a metal fixture, or even in your home, when you touched the showerhead fixture? And for dairy farmers, have you noticed a reduction in milk production? These may all be symptoms of stray voltage.

What is Stray Voltage?

Stray voltage is a small voltage (less than 10V as defined by the U.S Department of Agriculture) that can be measured between two possible contact points. When these two points are connected together by an object, such as a person or an animal, a current will flow. The amount of current depends on the voltage and the circuit impedance, which includes the source, contact and body impedances. People and animals respond to the resulting current flow and not to the applied voltage. Sometimes, it just takes a few milli-amps to create a mild sensation.

Where does Stray Voltage come from?

Due to the common grounding of the utility system and the customer electrical system, any neutral to earth voltage (NEV) on the utility system can be transferred to any grounded objects in a building, such as metal water pipes. Other possible sources of NEV can be the customer's own wiring system, a neighbor's wiring system, another utility such as the phone, cable, pipe line, or any combination of the above.

Load, leakage, and fault currents flowing through the impedances of the neutral or grounding conductors to earth, produce NEV. There are multiple paths from neutral or grounding system to earth such as ground rods, metallic water lines, or other ground electrodes. This means that there is always voltage to earth. Any metallic structure connected to the neutral or grounding system will also be at the same NEV. So, the question is not if there is stray voltage, but what is the safe level.

What is the problem and why is it important?

Because stray voltage is normally related to very low voltage and current, it sometimes is not detectable and therefore not a problem. However, when people start to get shocked, it becomes more of a safety-related issue and if not corrected, has the potential to be a bigger problem.

Stray voltage has become an issue with dairies, where cows in a dairy feel the effects and results in lower milk production. This has become an important issue in states like Wisconsin where now there are more installation and detection guidelines to help customers.

When should I be concerned?

It is recommended that actions be taken to reduce neutral to earth voltage when the NEV at the service entrance or between contact points is higher than the 2 to 4 volts range level. Unfortunately, there is no standard for stray voltage and this is only a recommended guideline from the U.S.

Department of Agriculture. However, there are on-going efforts to have it adopted as part of the National Electric Code (NEC).

However, when measuring for voltage and current, you need to stimulate the impedance of what you are measuring for. In the case of a cow, you need a typical impedance in the range of 500 ohm resistance. Another issue when measuring for current is the accuracy of the current transformer at very low magnitudes. Some handheld volt/ammeters can measure up to 10 amps directly without using a current transformer. Please refer to the *U.S. Department of Agriculture* document for more detail and information on this subject.

How to resolve a stray voltage problem?

There are four categories of mitigation approaches to control stray voltage:

a. Reduce the potential voltage source to an acceptable level. This includes correcting bad neutral connections and removing faulty loads; improving or correcting wiring and grounding; balancing load or controlling leakage current by cleaning, re-insulating or grounding.

b. Use active suppression of the voltage by a nulling device. A current is delivered to a remote grounding electrode to null out the measured voltage.

c. Use gradient control by use of equipotential planes and transition zones to maintain the animals' step and touch potential at an acceptable level. Also, in the National Electrical Code, Article 547, which covers Agricultural Buildings, Section 547.10 *Equipotential Planes (EP) and Bonding of Equipotential Planes* states that EP shall be installed in all concrete floor confinement areas of livestock buildings that contain metallic equipment that is accessible to animals and likely to become energized.

d. For some utility ground-neutral distribution systems, there may be current flowing from the customer grounded neutral system to the utility grounded neutral system. To reduce and minimize the impact of this, installation of spark gap, saturable reactor, or a solid-state switch can be used.

For more information on stray voltage please check out the following resources:

1. *Effects of Electrical Voltage/Current on Farm Animals: How to detect and remedy problems*. U.S. Department of Agriculture Handbook, December 1991. Handbook examines the following: 1) history of stray voltage/current problems on farms; 2) the physical and electrical sources of stray voltage/current phenomena; 3) the physiological and behavioral bases for losses in milk production; 4) methods for identifying and detecting stray voltage/current problems; 5) methods for mitigating such problems; and 6) areas where further research may be warranted. This handbook can be purchased from the National Technical Information Service, Technology Administration, U.S. Department of Commerce, Springfield, VA 22161 or by calling (703) 605-6000. The document number is NTIS Order No. PB92-172873.

2. *Equipotential Plane in Livestock Containment Areas, ASAE EP473.2 JAN 01*. American Society of Agricultural Engineers. 7 pages. This Engineering Practice is intended as a guide to engineers, technicians, and contractors for the design, layout, and construction of equipotential planes and voltage gradient ramps (transition areas) in livestock (excluding poultry) containment areas along with other specifications necessary to accomplish the following objectives: 1) provide a surface and surrounding such that all possible livestock or personnel contact points within the equipotential plane area are nearly the same electrical potential; and 2) provide minimum step and touch potential gradients for livestock entering or exiting from the

perimeters of an equipotential plane. This document can be purchased through ASAE web site at http://www.asabe.org/.

3. The Public Service Commission of Wisconsin has a variety of documents on the history, policies, experiences, measuring protocols, and reports on stray voltage. You can visit their web site at http://psc.wi.gov/utilityinfo/electric/strayvoltage.htm.

4. The Midwest Rural Energy Council has an excellent web site containing information on stray voltage. In particular, check out the following two documents. These documents can be downloaded free of charge at http://www.mrec.org/.

    a. *Equipotential Planes for Stray Voltage Reduction*. Installation Guidelines published by Wisconsin Farm Electric Council, 1996, 15 pages. Booklet gives an understanding of the function of an equipotential plane, how it can reduce the possibility of stray voltage, and how it can be installed at a farm.

    b. *Stray Voltage Detection, a Self-Help Guide*. Wisconsin Farm Electric Council, 1997, 11 pages. Booklet gives a basic understanding of stray voltage, some of its common causes, how to determine if it is a problem for your farm and when to call for assistance.